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'When Dual Sensory Mode with Limited Text Presentation Enhance Learning'

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Abstract

Advances in the knowledge of human memory suggest that under some circumstances, more processing capacity is effectively available to learners if instructional materials use multiple modalities (e.g. auditory for text and visual for pictures). According to cognitive load theory, some conventional approaches to instructional design are ineffective as they place an unnecessary load on a learner's working memory and cause learning to be hindered. Previous research, particularly in technically-based areas, has demonstrated that duplicating the same text in both visual and auditory formats may inhibit learning (audiovisual redundancy effect). However, it is not yet clear whether partial on-screen textual information (e.g., key words or phrases) presented simultaneously with fully narrated text would generate a similar negative effect or be beneficial for learning, especially when the language of instruction is a foreign or second language for the learners. Accordingly, the reported study examined whether supporting the narrated textual explanations of the related graphics in a visual form as key words or phrases would be more effective to learning in a realistic setting (and with English as a foreign language for the students) than the exact visual duplication of the narrated text. University students learned steps of psychosexual development since childhood up to adolescence period through audio text and graphics presented using PowerPoint slides and three different versions of the visual text: 1) the full text equivalent to the narrated explanations; 2) the reduced version of the text that presented phrases expressing major ideas in the text; and 3) key words representing main concepts. The pre and post- tests were conducted to evaluate levels of learner prior knowledge and post-instruction performance. The results indicated that the auditory explanations of the graphics supported by visual display of main phrases related to the explanations resulted in significantly better learning that either exact full visual duplication of the text or presenting only a limited number of key words. The study shows that supporting the audio explanations of graphics with visually presented on-screen phrases expressing main ideas of the text could be the most effective way of instructing learners for whom the language of instruction is a foreign or second language.

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1. Main text

Overhead text read aloud, text on a TV screen with a voice reading the same text, or instructional multimedia presentations including spoken narration with the same written text presented simultaneously on the computer

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screen are all familiar cases. When PowerPoint program is used in instruction, visual text is often provided on slides while lecturers repeat exactly the same information in spoken form expecting to benefit, learning and understanding. According to cognitive load theory and empirical evidence, this assumption can be incorrect. From a theoretical perspective, it is suggested that if learners are required to coordinate and simultaneously process redundant material such as written and spoken text, an excessive working memory load could be generated.

In a number of studies evaluating the benefits of multimedia instruction (e.g., Beccue, Vila, & Whitley, 2001; Hegarty, Quilici, Narayanan, Holmquist, & Moreno, 1999; Najjar, 1996; Tergan, 1997), redundant information presentation in different modalities (i.e., presenting the same information in written and spoken form) did not bring about the expected positive effects on learning. Establishing relations between different sources of information may be difficult for learners dealing with multiple representations (Van Someren, Reimann, Boshuizen, & de Jong, 1998). It has been demonstrated that redundancy can interfere with learning (see Mayer, 2001; Sweller, Ayres, & Kalyuga, 2011; and Sweller,Van Merrienboer, & Paas, 1998, for reviews). The reasons are reside in the human cognitive architecture (Sweller et al., 2011). Novel information must be handled by working memory and, as is well known, only a few units of information can be processed in working memory at any time (e.g., Baddeley, 1998). Overburdening of working memory may result in decreased effectiveness of information processing. Both cognitive load theory (Sweller et al.,2011) and cognitive theory of multimedia learning (Mayer, 2009) have been developed to explore the instructional consequences of this fundamental feature of human memory. Working memory may be overburdened if instruction involves excessive elements of novel information processed simultaneously. However, there may be no limitation in the number of familiar, well-learned elements that can be processed in working memory (Ericsson & Kintsch,1995; Sweller, 2003). Knowledge is held in long-term memory in the form of hierarchically organized schemas, allowing experts to treat many elements of information as a single element, thus reducing demands on working memory. Appropriate allocation of cognitive resources is important to efficient learning, especially for relative novices in a domain. In situations where a significant share of working memory resources is assigned to activities not directly related to schema acquisition, learning may be inhibited.

Dual-processing models of memory consider capacities to be distributed over separate auditory and visual channels (Baddeley,1998; Penney,1989;). For example, in Baddeley's (1998) model, the phonological loop processes auditory information, whereas the visual-spatial sketch pad deals with visual information such as diagrams and pictures. Paivio's (1990) dual coding theory also suggests that information can be encoded, stored, and retrieved from two fundamentally distinct systems, one suited to verbal information, the other to images. Penney (1989) proposed a model of working memory in which the processing of auditory and visually presented verbal items is carried out independently by auditory and visual processors in working memory.

Dual-mode presentations may effectively expand working memory capacity if one part of the instruction (e.g., textual explanations) is presented in auditory form and the other (e.g., a diagram) in visual form,Mayer and Moreno (1998) and Moreno and Mayer (1999; see Mayer,2009,for a recent review), Mousavi, Low, and Sweller (1995), and Tmdall-Ford, Chandler, and Sweller (1997) demonstrated the superiority of audiovisual instructions. Learning was more effective when the words were presented auditorily rather than visually because using auditory and visual processors in working memory effectively eliminated cognitive overload of the visual channel.

When learners are required to integrate several sources of information , that have an identical information content, a redundancy effect may occur .If additional sources of information simply re-describe the same subject, such a duplication may cause a cognitive overload. Attending' to redundant information consumes cognitive resources that become unavailable for processing essential information. Eliminating redundant information frees these resources for learning (Chandler & Swe}ler, 1991; Sweller & Chandler, 1994).Kalyuga, Chandler, and Sweller (1999, 2000) observed conditions where the addition of concurrent audio explanations to visual instructions had negative rather than positive or neutral effect on learning.

The measures of cognitive load used in those studies suggested that duplicating verbal information in different modalities was likely to impose an excessive load on working memory. It was assumed that the need to attend, coordinate, and process both modes of text simultaneously, and to relate them to other graphic information, consumed additional cognitive resources and thereby overloaded working memory capacity and hindered learning. Similar results were obtained by Moreno and Mayer (2002) and by Mayer, Heiser, and Lonn (2001). If the same two sources of information are processed simultaneously (e.g., listening to and reading the same text), concurrent processing of modules of identical information might exceed working memory capacity and thus decrease the effectiveness of learning. However, it is not yet clear whether partial on-screen textual information (e.g., key words

or phrases) presented simultaneously with fully narrated text would generate a similar negative effect or be beneficial for learning, especially when instructing is in language that is a foreign or second language for the learners. There have been indications, that abbreviated versions of spoken text (e.g. key words) could have positive effects on learning (e.g., Mayer & Johnson, 2008). The reported study examined whether supporting the narrated textual explanations of the related graphics in a visual form as key words or phrases would be more effective to learning in a realistic setting (and with English as a foreign language for the students) than the exact visual duplication of the narrated text.

2. Method

***Participants*:** The experiment was conducted in a realistic environment of a lecture in general psychology. The sample was 523 Thai students age 19 to 22 years for whom English was a foreign language

Materials and procedure: Students learned steps of psychosexual development since childhood up to adolescence period (the content that was not familiar to the students) through audio text and graphic presented using PowerPoint slides and three different versions of the visual text: 1) the full text equivalent to the narrated explanations; 2) the reduced version of the text that presented phrases expressing major ideas in the text; and 3) key words representing main concepts. The pre and post- tests were conducted to evaluate levels of learner prior knowledge and post-instruction performance

Participants were randomly allocated to three groups corresponding to the three instructional formats: 109 students in the key words group, 173 students in the full on-screen text group and 241 students in the phrases group.

Pre-test consisted of 10 questions regarding the background of psychosexual development. The test included six multiple-choice questions (e.g. 'Thumb sucking' is the action of the child age between….. … years': a) birth – 1.8; b) 1.8 – 3; c) 3 – 6; d) 6- 12) and four questions based on matching corresponding items in two different columns (one listing developmental stages and another listing characteristics of the stages).Performance test consisted of 20 multiple-choice questions (with four alternatives for each question) Participants had to demonstrate their knowledge of the development of psychosexual characteristics.

3. Results and Discussion

Analysis of variance for pre test scores showed a highly insignificant difference between the three groups thus indicating that students in those groups were at the same level of prior knowledge, and there were no initial advantages to any group prior to the instruction phase. Analysis of covariance for the post-test performance scores (with pre-test scores as a covariate to take into account any individual differences in learner prior knowledge) indicated a significant difference between the three conditions, $F(2, 519) = 54.78$, $MSe = 2.23$, $p < 0.001$ ($M = 7.32$, $SD = 1.96$ for the full on-screen text condition; $M = 7.45$, $SD = 1.59$ for the key words condition; and $M = 8.83$, $SD = 0.98$ for the phrase condition; maximum possible post-test score was 20. Bonferroni post-hoc tests indicates that the phrase condition significantly outperformed the other two conditions with no significant differences between the full text and key words conditions.

The results indicate that for students who learn in a language other than their native one, the written back-up of spoken textual information could in fact be effective by providing a form of support for dealing with the transient nature of spoken words. The multimedia redundancy effect that suggests avoiding any written duplication of spoken information may not occur with these learners. However, according to this effect, providing a full written duplicate of the narrated text still was sub-optimal even for these learners. Also, as they needed an additional support while listening to the explanations, displaying only visual key words could not provide a sufficient level of support (key words group performed at the same level as the full-text group). The results showed that providing meaningful phrases expressing main ideas of the explanatory text is the best instructional format for these learners. Future studies need to include the control group (with spoken-only explanations) as well as investigate the effect of different levels of learner expertise both in content matter and in students' mastery of the language of instruction (e.g., using instructions in native language or using learners at different levels of experience in a foreign language). Such research studies could further refine the conditions of applicability of the multimedia redundancy effect.

4. Implications for Instructional Design

The common instructional procedure (particularly in multimedia instruction and in PowerPoint supported lectures) of presenting identical spoken and written material simultaneously may need to be avoided. If written material needs to be presented to support spoken text (e.g., for learners whose native language is different from the language of instruction), on the evidence of the current experiment, it should be presented with not too many but not too few visual words on the slides. Providing meaningful phrases expressing main ideas of spoken explanations could be the most effective instructional format in such situations. Further work needs to be carried out to establish more specific instructional guidelines for the optimal size of textual information.

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